Kipp & Zonen

LUX *LITE*

INSTRUCTION MANUAL

p.o. box 507	2600 AM	Delft Holland	0347200
Röntgenweg 1	2624 BD	Delft Holland	9909

Tel. 015-2698000
Fax. 015-2620351

Notice
Please read this manual before using the LUX *LITE.*
The manufacturer shall not be liable for incidental or consequential damage in connection with the furnishing, performance or use of this manual and the sensor that is described in this manual.

Contents

1		General information	3
	1.1	*Five minutes user guide*	5
2		Sensor properties	7
	2.1	*Electrical*	7
	2.2	*Spectral*	9
	2.3	*Directional / Cosine response*	11
	2.4	*List of specifications*	13
	2.5	*Expected output levels*	16
	2.6	*Dimensions*	18
3		Calibration	19
4		Installation and maintenance	21
5		Trouble shooting	25
6		Delivery	27
7		Accessories	29

1General information

The LUX *LITE* is a photometer for the measurement of illuminance. The International Commission on Illumination (CIE) defines this quantity as the quotient of luminous flux received by an area element, and the area of that element. This type of instrument is generally known as a Lux meter. The Lux meter has a spectral sensitivity as the human eye. This spectral sensitivity is generally referred to as V(λ), or sometimes the Standard Observer Curve. The measurement is therefore typically used in applications where the human observation is the central item. LUX *LITE* measures the photons that are received from the entire hemisphere (180 degrees field of view). The output is expressed in lux.

The LUX *LITE* is designed for continuous outdoor use. Its calibration is valid for natural sunlight, for artificial light it will be less accurate. See the section on spectral sensor properties and calibration.

In its most frequent application the lux sensor is used for the measurement of natural daylight in climatological and meteorological applications. Typically it will be installed in a measurement station and face upwards. It can however be used to measure in an inverted or in a tilted position.

Contrary to similar designs of other brands, the LUX *LITE* is not equipped with a level. The reason is that for the kind of accuracy that this sensor can offer, leveling can be done once-only with a level instrument.over the diffusor and rim. A leveling fixture is available as an option.

The applicable standards for the LUX-Lite are CIE publication No 69 (1987) Method of Characterizing Illuminance Meters and Luminance Meters, DIN 5031 Lichtmessung, Photometer, Begriffe, Eigenschaften und deren Kennzeichnung and DIN 5032, Lichtmessung, Klasseeinteilung von Beleuchtungsstaerke- und Leuchtdichtemessgeraete.

The LUX-LITE fully complies CE with directive 89/336/EEC

1.1 Five minutes user guide

Requirements:
1. LUX *LITE*
2. voltmeter with a range from 0 to 20 millivolt and an input pedance of more than 50 kΩ
3. light

- Connect the white wire to the voltmeter+, the green wire to the voltmeter-, the shield to the ground.
- Position the instrument as such that the sensor is parallel to the surface that you want to investigate.
- Put the voltmeter to the most sensitive range.
- Darken the sensor. The signal should read zero.
- Expose the sensor to light. The signal should give a positive reading.
- Adjust the voltmeter range in such a way that the expected full-scale output of the LUX *LITE* fits the full-scale input of the voltmeter. This can be done on theoretical considerations. (When the maximum expected radiation is 100 000 lux, and the sensitivity of the LUX *LITE* is 0.1 microvolts per lux, the expected output range of the LUX *LITE* is 100 000 times 0.1 makes

10 000 microvolts or 0.01 volts.) Please note that the calibration is valid for natural sunlight only.

- Calculate the light intensity by dividing the LUX *LITE* output (10 000 µV) by the calibration factor (0.1 µV/lx).

- For permanent installation mounting should be done using the holes through the LUX *LITE* body, or through the holes in the optional leveling fixture. The LUX *LITE* should be mounted in a field that is free from obstructions Unless this is unavoidable, no shadow should be cast upon it.

- Maintenance: the meter should be kept clean, using water or alcohol.

- Recalibration is suggested every two years, preferably by letting a higher standard run parallel to it during two sunny days, and by comparing the daily totals.

2 Sensor properties

The LUX *LITE* consists of a photodiode, a filter,a diffusor, a housing and a cable.
A resistance shunts the photodiode. This is done to generate a voltage output. The photodiode and the resistor determine most electrical specifications. The photodiode, the filter and the diffusor on top determine the spectral specifications. The diffusor ensures a field of view of 180 degrees, and that the angular characteristics fulfill the so-called cosine response.

2.1 Electrical

The electrical circuit of the LUX *LITE* is drawn in figure 1. The output resistance of the LUX *LITE* is 560 Ω. This implies that the input impedance of the readout equipment should be at least 56 kΩ in order to make an read-out error of less than 1 percent.
The cable can be extended without problems to a length of 100 meters, provided that cable resistance is less than 0.1 percent of the input impedance of the readout equipment.
The electrical sensitivity of the photodiode changes with the temperature. A mean value for this is -0.15 percent change per degree Celsius.
Calibration is done at 20 degrees Celsius nominal.

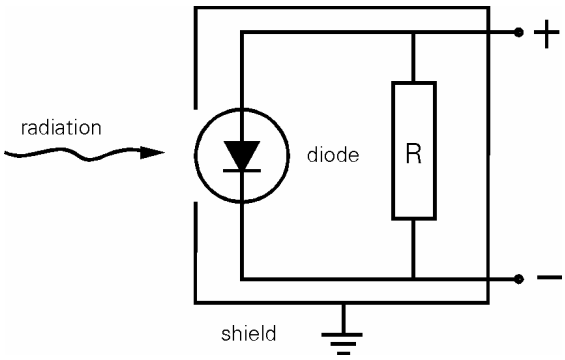

Figure 1 Electrical circuit of the LUX meter, white +.

2.2 Spectral

The spectral properties of the LUX meter are mainly determined by the properties of the photodiode and the filter. These are indicated in figure 2.

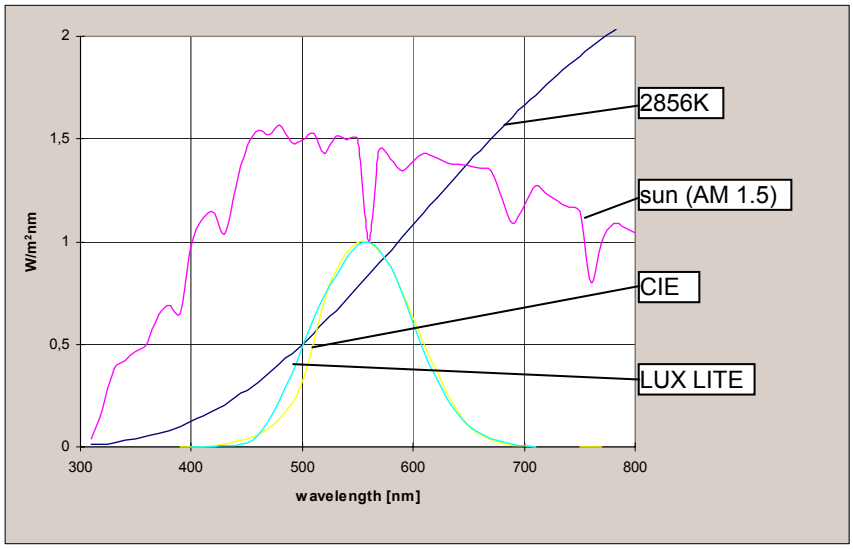

Figure 2. The relative spectral sensitivity of the LUX *LITE and the CIE V(λ) curve combined with the spectrum of the sun under a clear sky (airmass 1.5) and the relative spectrum of a lamp with colortemperature of 2856K.*

The spectral sensitivity of the LUX *LITE* should follow the characteristic of a standardized curve, V(λ), which follows the

sensitivity of the human eye for daylight conditions. The deviation of the LUX LITE spectral sensitivity relative to the perfect curve can be read in fig. 2 and in the section on specifications.
Luxmeters with perfect curve have the same accuracy in daylight as in lamplight.although the spectral emission of lamps can differ significantly from the sun. The LUX-Lite, with its non-perfect curve and calibrated for natural daylight, does not necessarily give an accurate measurement under the light of lamps. The specifications in this respect strongly depend on the type of lamp that is used.In fact a luxmeter with non-perfect spectral response has for each light spectrum another sensitivity (mV/100 klx). Recalibration for your lightspectrum is often possible at National Standard Institutes. Deviations can be of the order of magnitude of +/- 5% percent. Please contact your supplier for specific information.

The spectral sensitivity of the photodiode and filter change only slightly with temperature. The centerwavelength drift of the filter < 0.1 nm/K and total transmittance and bandwidth is said to be temperature independent.
This is the reason why the temperature dependence of the spectral sensitivity is not specified.

2.3 Directional/Cosine response

The measurement of illuminance is laid down in two detector specifications: that the detector has a correct spectral response V(λ), and that it has a field of view of 180 degrees. Another way of expressing the latter directional properties is to say that the sensor has to comply with the cosine response.
A perfect cosine response will show maximum sensitivity (1) at an angle of incidence of 0 degrees (perpendicular to the sensor surface) and zero sensitivity at an angle of incidence of 90 degrees (radiation passing over the sensor surface). In between 0 and 90 degrees the sensitivity should be proportional to the cosine of the angle of incidence. Figure 3 shows the behavior of a typical LUX sensor. The vertical axis shows the deviation from ideal behavior, expressed in percentage of the ideal value.
It is important to realize that the cosine specification of a sensor that is used under outdoor conditions is particularly important because there is a dominant source, the sun, that constantly changes azimuth position, and that can also be situated at very large zenith angles (low solar elevation).

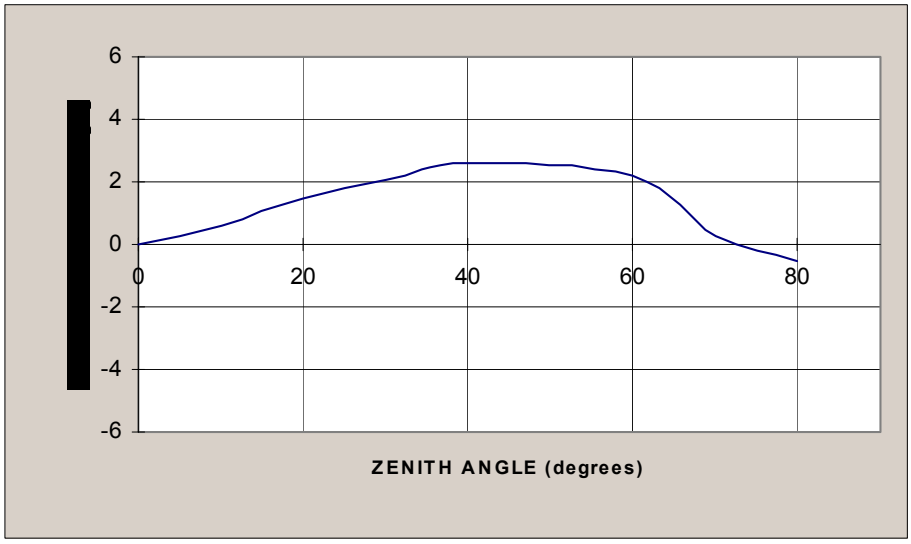

Figure 3. Typical mean directional response or cosine response of the LUX *LITE. On the horizontal axis the zenith angle On the vertical axis the percentage deviation from ideal cosine behavior.*
The curve can lift or fall for different azimuth (+ or - 2.5% at 70° zenith angle).

2.4 List of specifications

Electrical

• Impedance (nominal):	680 Ω
• Response time:	< 0.1 s
• Sensitivity (nominal):	10 mV/100klx
• Range:	0 - 200 klx
• Expected signal range under atmospheric conditions:	0 – 15 mV
• Stability:	< 2 %/year
• Non linearity:	< 1 % up to 100 klx
• Temperature dependence of sensitivity:	< 0.2% / °C (-0.15typ)

Spectral

- Spectral response: equivalent to the human eye response
- Centerwavelength (CWL): 550 – 560 nm
- Bandwidth (50 % points) FWHM 103 +/- 5 nm
- Bandwidth (10 %) 180 +/- 5 nm
- V(λ)-match error < 5 %

- Detector type: Silicon photodiode plus filter

Directional

- Cosine corrected
- Error up to 80° angle of incidence: < 10 %
- Mean cosine error (f_2 acc. DIN5032) < 3 %
- Azimuth error (at 70° angle of incidence): < 5 %pp

- Tilt response: no error

Mechanical

- Material of housing: Anodized Aluminium
- Material of cable: Poly Urethane
- Weight: 110 g
- Cable length: 3 metres
- Dimensions see figure 4

Environmental

- Operating temperature range: -30 - +70 °C
- Humidity 0 – 100 % RH

2.5 expected output levels

Cloud condition	Pyranometer reading W/m^2	LUX sensor reading lx	lx.m^2/W +/- 20%
Cloudless	Typ 0 to 1300	Typ 0 to 140000	110 +/- 10%
Cloudy	Typ 0 to 500	Typ 0 to 70000	138 +/- 20%

Table 1: Conversion from W/m^2 to lx under cloudless and cloudy conditions. The table serves as a rough crosscheck when also measurements of the solar irradiance in W/m^2 are available.

Cloud condition	Pyranometer daily total $W.h/m^2$	LUX sensor daily total klx.hr	
Cloudless	Up to 11000	Up to 1200	
Cloudy	Up to 4500	Up to 600	

Table 2: expected daily totals; the figures are indicative

2.6 Dimensions

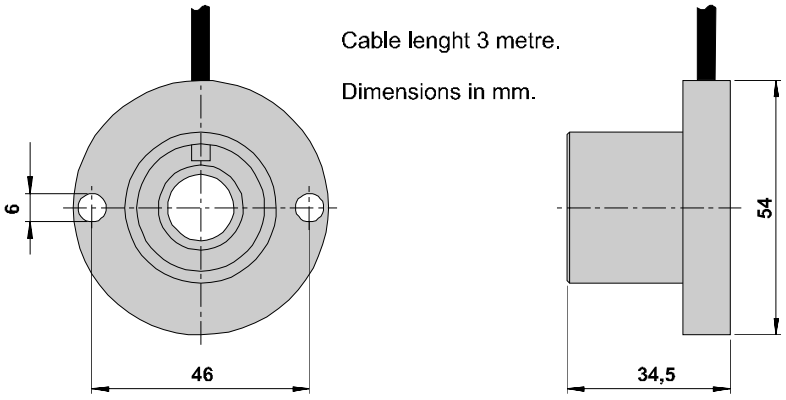

Figure 4. The dimensions of the LUX LITE in mm, white lead positive, green lead negative.

3 Calibration

Reference luxmeters can be calibrated using a standard of kwown illuminance, preferaby illuminant A. Illumant A is an incandescent source of unpolarized light with colortemperature 2856K. The reference LUX *LITE* is calibrated against such a source, e.g. the photometric standard lamp of Osram type Wi 41/G, which on his turn is calibrated at the dutch standard laboratory NMI.
Afterwards the reference LUX *LITE* sensitivity for hemispherical solar radiation at airmass 1.5 (according international standard ISO 9845-1) is calculated from the light spectra as in fig.2.

The normal production units are calibrated by an indoor comparison in a parallel beam of light from a Xenonlamp. The visible lightspectrum of a Xenonlamp closely resembles that of the sun and is rather flat. The illuminance of this beam is measured periodically by the reference LUX *LITE*. Further reference conditions are as follows: temperature 25 degrees Celsius, illuminance 10 $\pm$ 1 klx and normal incidence radiation. Thus, the LUX *LITE* sensivity is most accurate for measurement of daylight (direct sun + sky) at airmass 1,5 (sun's zenith angle 37°).

4 Installation and maintenance

When installed permanently, the LUX *LITE* can be attached to its mounting platform using the holes that are drilled through the body. The holes are standardized to Kipp & Zonen design. Leveling can be based on your own visual observation. Preferred orientation is with the cable pointing away from the equator (this prevents excessive heating of the leads). When installed on a mast, preferred orientation is such that no shadow is cast on the LUX *LITE* during any time of the day. On the Northern Hemisphere this implies that the LUX *LITE* should be south of the mast.

The LUX *LITE* can be used to measure reflected radiation, for instance when pointed towards the earth in the inverted position. The accuracy of this measurement however will be less than a measurement facing upwards, because the spectrum of the reflected radiation differs from the natural daylight spectrum. When measuring reflected radiation it is advised to measure at a height of at least 1.5 meters above the surface in order to avoid shading effects and to promote spatial averaging.
The LUX *LITE* is an all weather instrument.

Once installed the LUX *LITE* needs little maintenance. It is suggested to clean the detector as part of a regular routine, using water or alcohol.

Recalibration is suggested every two years. This can be done in two ways. The first is by comparing with the measurement of a similar sensor at the same site. Preferably daily totals of several days should be compared. Calibration factor could be corrected if results differ by more than five percent.
The second way is to let a recalibration be performed at the LUX *LITE* factory.

Adjustment of the calibration factor

If necessary, the sensitivity of the LUX *LITE* can be adapted. This can be done by soldering a resistor between the + (white) and - (green) output wires. In this way the internal resistance is shunted. The nominal internal (load) resistance R_l is 560 ohms, the cable resistance is about 0.1 ohms per meter. (To be sure, measure the impedance of the LUX LITE with an Ohmmeter, in the correct direction (reverse voltage on photodiode)). Neglecting the cable-resistance, a shuntresistor R_p gives a new sensitivity $S_{new} = S_{old}.R_p/(R_l + R_p)$.

Measuring modulated light

To measure modulated light, e.g. fluorescent light, it is necessary to shunt the LUX *LITE* with a capacitor. The LUX *LITE* has a response time < 1 ms and much read-out equipment cannot handle the resulting voltage pulses. At principle you must bring the RC time above the period time of the lightpulses to get a smooth signal. Due to the relative low impedance of the LUX *LITE* this need a big capacitor of about 100 µF. Electrolytic capacitors are however useless due to their battery effect. So use polyester, ceramic, etc types.

5 Trouble shooting

If your LUX *LITE does not seem to work at all, please follow the following procedure:*

- Check if the LUX *LITE* reacts to light, using the procedure in the "five minutes user manual".
- No result? Measure the impedance of the sensor across the white and the green wires in the dark. With reverse voltage across the photodiode this should be 560 Ohms. If it is close to five Ohms, there is a short circuit. If it is infinite, the circuit is blown.
  With forward voltage across the photodiode you will mostly measure a resistance < 560 Ohms if the photodiode-circuit is OK.

If the LUX *LITE shows bigger or smaller results than expected, the following questions might help you out:*

- Are you measuring under natural sunlight? If so the maximum expected radiation is 140 000 lux.
  Under lamps this might be more.
- Are you correcting for the calibration factor? Please note that this factor is an individual property and is different for each sensor. Do you divide by the factor? This is correct.
- What is the input impedance of your readout equipment? It should preferably be more than 50 kOhm ohm. If smaller than 5000 Ohm you will notice errors of more than –10 %.
- Is your readout equipment properly calibrated?

If still no satisfactory answer is found, please contact your supplier.

6 Delivery

Delivery includes

1 LUX *LITE*
1 calibration certificate
1 manual

7 Accessories

CLF1 leveling fixture.